KONINKLIJKE AKADEMIE VAN WETENSCHAPPEN
TE AMSTERDAM

PROCEEDINGS

VOLUME XXXVI

No. 8

President: J. VAN DER HOEVE
Secretary: B. BROUWER

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Physics. — *The problem of the unit of light.* By L. S. ORNSTEIN.

(Communicated at the meeting of September 30, 1933.)

Since many years the problem of the unit of light is discussed in the cercles of technical science. In many contries the international lumen or the Hefner candle are legal unit, however, a scientific problem cannot be solved by law.

For the solution of the eminent practical problem of the photometry of lamps a number of incandescent lamps with carbon filament are kept as primary standards of light in the National laboratories. By comparing those lamps an international scale of light intensity is maintained.

If the measurement of the commercial lamps ought to be performed, a difficulty rises by the fact that the temperature of the carbonlamps is rather low so that their radiation is yellow, while the colour of the usual lamps is much more white. The difficult problem of heterochromatic photometry rises. This fact and also the differences between the standards of the National laboratories caused that the wish occurred to get a standard of such physical properties that its radiation under given circumstances would be reproducible and would furnish a distribution of the energy as a function of wavelength known in absolute measure. The importance of the black body radiation from theoretical standpoint suggested to choose a black body as a primary standard of light. Indeed if the temperature of such a body is known and if its blackness is sufficiently tested we would have a radiator with known energy radiation, given by the Planck-formula. There is no objection against taking such a black body as a primary standard, if only the measurement of temperature and the control of the black body character is possible with sufficient accuracy — and if further at the other side the problem of the heterochromatic photometry is solved. It is therefore necessary to develop methods of measurement for this control — and if we possess such methods, the importance of the black body as a primary standard falls away.

Before we shortly discuss the methods of measurement it is good to dwell still on the significance of the standard.

Suppose that we have a standard black body of given temperature then we ought to compare with this standard a light source of another temperature, we come therefore again to the difficulty already mentioned of comparing light sources of different colour. In order to express the intensity of a lamp in the standard as an unit, we want a method of comparing the brilliancy of light sources of different colour. This problem is however not a determined one; as it is necessary to judge the brilliancy using a

given criterion. If observers try to compare the brilliancy of a light source differing in colour some of them cannot (among them is no one less than HELMHOLTZ) give a determined decision, others however — but generally with small accuracy and reproducebliness — are able to state in this case equality of brilliancy. Several methods have been developped to avoid the mentioned difficulty, all based on different criteria of equal brilliancy — I will however not dwell on this methods. One thing ought to be noticed, — the judgment of equality of brilliancy has only significance in connection to the criterion used. The value of this judgment from the standpoint of the lightning technique therefore is unknown. The fact that the difference of colour is totally neglected is a serious drawback from technical (and scientifical!) standpoint.

It is possible to determine for every wavelength the proportion of the energies of a standard and an arbitrary light source. The last can be expressed in the standard as an unit if the physiological effect of the different colours is characterised by numbers. The curve of sensitivity of the eye must be introduced. The number of units of the unknown lightsource is expressed in the standard by multiplying for the whole range of wavelength in the visible, the proportion of the energies with the eye sensitivity for the colour and adding the results. There are objections against this method. We must remark in the first place that the eye-sensitivity curve is dependant on the criterion used by its determination and that it can only be determined as a mean value.

If one compares a coloured source light f. i. a Sodium lamp with a continuous source one is struck by the "very relative value" of the number expressing the first source in the standard of light. If those two lamps have the same brilliancy defined in this way, their action as a source of illumination is quite different, and what is so evident in this extreme case is more generally true for continuous sources of different colour.

As we have already urged the control of the black body or any other light standard claims the necessity of a method of measurement, but at the other side this method can be substituted for the standard. In the Utrecht Institute such a method has been developed. Summarising the method is the following. A monochromatic image of known spectral width is formed by a monochromator and lenses from an arbitrary but constant light source.

The coloured image is measured absolutely with a thermopile. The intensity of an unknown light source for any wavelength can be compared spectroscopically with the image of the first source — the "image source". This image is the comparison source in the second measurement; it enables to eliminate the selective properties of the receptor.

In the original Utrecht method the comparison of the unknown and the

image light source was effected with the help of a spectrophotographic method to an accuracy which amounts 2—3 %, an accuracy which was far sufficient for the work on spectral intensities bearing to atomic physics. In the discussion at the Cambridge meeting of the I. I. C. this accuracy was considered to be too small for illumination problems, and a greater accuracy was thought necessary. At this purpose investigations are done in the Utrecht Institute with the cooperation of Miss EYMERS and Mr. VERMEULEN for the relative intensity measurement and of Mr. WOUDA for the absolute measurement. Using vacuum thermopile and a new vacuum bolometer combined with the MOLL—BURGER thermo-relais and measuring in a very accurate way the regions of wavelength originating from the monochromator or spectroscope, it was possible to attain for the relative measurement an accuracy of 1 $^0/_{00}$. In the relative measurement photoelectric cell as well as the Utrecht spectral-pyrometer could be used.

The measurement of the absolute intensity met with serious difficulties. Using other principles (pyrheliometer) it was already possible to attain an accuracy of 1 %. The great difficulty for the promille precision of the absolute measurement form for the moment the small deviations in thickness of the manganine films used. However the accuracy is already sufficient now to put the thesis that the only right way to characterise a light source is — to indicate the distribution of the light energy as a function of wavelenght and its distribution in space.

For practical use substandards are useful which can serve to determine in a quick way the wavelength distribution of the energy. These standards can be calibrated with the method described. The method should be fixed by international agreement.

In this way the measurement of light is reduced to the c.g.s. system.

I will indicate two methods for determining in a quick way the energy distribution.

The first method gives the total flux of energy.

An unknown light source can be compared energetically with a known in the following way.

Put the known light source in an Ulbricht sphere and measure the intensity of the photometric screen with spectral pyrometer. Now put the unknown source in the sphere and measure again if the pyrometer is standarised for the intensity in each wavelength the comparison of the intensities of the lamps is possible for any wavelength in the visible. It is easily possible also to give the lumen value of the unknown lamp if the lumen value of the known lamp is given. The only assumption necessary is that of an eye-sensitivity curve. If we adopt any, the calculation is possible as an example given below gives the measurement for a lamp.

If it would be desirable — what is denied by the author — to keep the lumen as unit the best proceeding would be the following:

Define a lamp with an adopted distribution of energy as possessing a

chosen number of lumen. Adopt an eye-sensitivity curve, than in the way described the brilliancy of any lamp can be expressed in lumen.

	Secondary standard.			Unknown lamp	
λ	Energy	Eye-sensitivity	Energy x eye-sensitivity	Energy	Energy x eye-sensitivity
6800	78	0.017	1.32	174	2.65
6600	70	0.061	4.37	162	9.8
6400	61.5	0.175	10.8	147.7	25.8
6200	53.5	0.384	20.4	134	51.1
6000	45.7	0.631	28.9	120	76.0
5800	38.6	0.870	33.5	106	92.0
5600	31.9	0.995	31.7	92.5	92.0
5400	25.8	0.954	24.6	79.5	75.8
5200	20.4	0.710	14.5	66.5	47.2
5000	15.8	0.323	5.1	55.0	17.8
4800	11.8	0.139	1.64	42.2	5.85
4600	8.6	0.060	0.52	34.2	2.05
			177.3		498.0
	Tc 2400 K.			Tc. 2826 K.	
	Number of Lumen 476			1340.	

Miss EYMERS and Mr. VERMEULEN have given a method which enables to measure the flux of light in any direction by direct comparison of a black body of law temperature. (Compare these Proceedings 34, 1930). This method has been published in full detail in Revue d'Optique of Nov. 1933. I will shortly mention the principle here. The black body is used in order to calibrate the Utrecht spectral pyrometer (these Proceedings 35, 278, 1932) in absolute measure i.e. the pyrometer current corresponding with the brilliancy of the black body for chosen wavelength is determined; the relative calibration for each colour can be operated as described in the paper mentioned above.

The method proceeds further in the following way. A white plane (fig. 1) is illuminated by an arbitrary but constant source L and the brilliancy in the direction b measured by the pyrometer (and expressed in the known black body brilliancy). The light (fig. 2) going in the direction b illuminates a white plane B. Knowing the surface and mutual situation of A and B the brilliancy of B can be expressed in that of A which is known. The brilliancy in the direction c is measured with the

pyrometer, and as B has a known brilliancy we calibrate in absolute measure the pyrometer for the fixed direction c. Now taking away

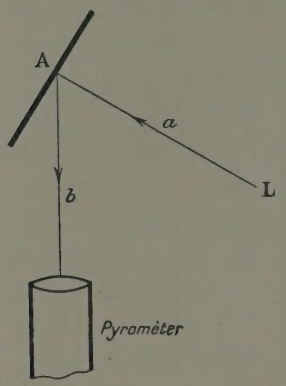

Fig. 1.

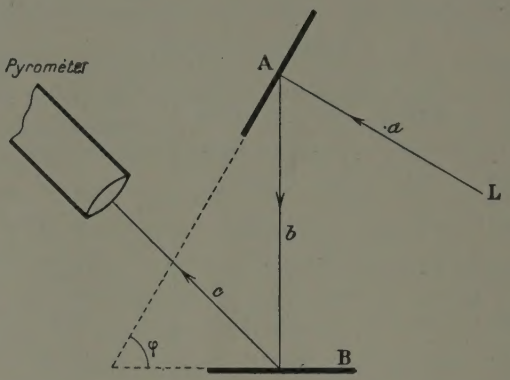

Fig. 2.

L and A and putting an unknown light source in A, we can measure the flux of light going in the direction b by the pyrometer which was calibrated following the method described.

The given methods enable the calibration of any lamp — it can be applied as well for continuous as for sources emitting lines. For continuous sources the problem can, if the accuracy ought not to be very great, be simplified; with fairly good approximation the relative intensity distribution in the visible is given for such sources by a Wien law, the temperature characterising this law, the colour temperature, is sufficient for the description relative of the distribution and only one further absolute value of energy is necessary.

We want at least two numerical data in order to characterise a continuous source — the lumen value alone is quite insufficient.

It is perfectly without sence to speak of the lumen-value of light sources emitting lines and it is also dangerous as the value of such sources in practice is not determined by this "fictive" lumen value.

The development of the science of illumination only can be advanced by the canceling of the lumen as an unit and by replacing it by quantities which are defined in purely physical way and can be measured by exact physical methods. The study of the problems still open in illumination which are physiological and psychological will be promoted, the illumination engineer will see in this way better what is the real problem not longer being embarrassed by the only apparant certainty of the lumen.

Summary.

1. The radiation of a light source ought to be expressed in the energy in absolute measure, as function of wavelength and distribution in space.

2. A standard method of calibration has been worked out, now with an accuracy of 1 $^0/_{00}$ for relative and 1 % for absolute measurement.

3. A method is described which enables to calibrate quickly:
   a) substandard for total radiation.
   b) substandard for radiation in a given direction, the last with the help of a black body of low temperature.

4. By the definition of a given energy distribution as „a lumen" and the fixation by definition of an eye-sensitivity curve, it is possible by the methods of 3 to measure the lumen value of any lamp.

5. For lightning practice the lumen unity is not suitable. For continuous sources (Incandescent lamps) only colour-temperature and the value one energy in absolute measure are sufficient data.

Astronomy. — *On the Collaboration between the Observatories of Johannesburg and Leiden concerning photographic Measures of Double Stars.* By EJNAR HERTZSPRUNG.

(Communicated at the meeting of September 30, 1933.)

Originally the collaboration between the observatories of Johannesburg and Leiden was merely confined to variable stars, the plates being taken in Johannesburg and generally worked up in Leiden.

Since the erection of the 67 cm visual refractor at the Union Observatory this instrument has been used by W. H. VAN DEN BOS and W. S. FINSEN principally for micrometrical measures of double stars. However, a commencement has been made also to photograph double stars with this refractor. The way, in which this is done, is the same as that formerly used by the writer in Potsdam and described in Potsdam Publ. N°. 75; 1920. The main points of the procedure are the following:

1. The photographs are taken — preferently with a visual refractor — behind a yellow screen on erythrosinsilverplates, which show a sharp maximum of sensitiveness for light of wavelength about 550 m μ. In this way white and yellow stars show practically the same effective wavelength and (consequently) also refraction.

2. Four different coarse gratings, to be placed in front of the objective, are used giving respectively 1, 2, 3 and 4 magnitudes difference between the central image and the diffraction images of the first order. The mean of the positions of the two diffraction images of the brighter star is used instead of the position of its central image. In this way the difference in magnitude between the two components of a double star is practically compensated, thus avoiding a possible magnitude equation.

3. The measures are made by micrometrical motion of the plate (or of the microscope). In this way constancy of the screw value is guaranteed in contradistinction to the case, where an eyepiece micrometer is used. This point is of special importance because:

4. The plates are measured both in the ordinary way with the film turned towards the microscope and through the glass, the plate being turned between the two measures through 180° round an axis parallel to the pointing thread of the microscope. The idea is to eliminate systematic errors arising from inaccuracy in the orientation between the axis of the screw, the pointing thread of the microscope, the motion of the plate at right angles to the micrometerscrew and the motion of the microscope, which last motion is used for the quick orientation of the plate in the co-ordinate parallel to the daily motion.

The precautions mentioned are partly considered as necessary for obtaining accurate results and partly as convenient means for automatical elimination of errors, which it would be circumstantial to determine and to take into consideration.

The number of exposures on one plate is ordinarily between 25 and 100. So far about 300 more or less successful plates have been taken by W. H. VAN DEN BOS and W. S. FINSEN, of which a few together with the writer. Up till now about 80 of these plates have been measured in Leiden using a machine of the kind described above and achieved through a personal grant from the Danish Carlsberg Foundation.

As an example of the results obtained I have chosen the 11 plates of α Centauri taken between 1929.2 and 1932.5 and listed in the accompanying table.

The scale of the plates is 1 mm = 18″.9.

The numbers n_f and n_g indicate how many exposures have been measured respectively with the film in front and through the glass. The mean errors given for $\triangle\alpha \cos\delta$ and $\triangle\delta$ are derived from the internal agreement of the different images. The plates marked B: VAN DEN BOS and φ: FINSEN were measured at the Johannesburg Station of the Yale Observatory and the rest in Leiden by the writer.

The values of *O-C* have been derived by comparison of the observations with the orbital elements $M = 4^{o/a}.5$ $(t - 1875^a.76)$, $e = .52$, $G = + + 8''.6200$, $B = +6''.9769$, $F = -13''.4128$ and $G = -4''.2323$, where n, T and e have, slightly rounded off, been taken from U. O. C. 68 (orbit by FINSEN). The THIELE-elements as modified by INNES, A, B, F and G, were then derived from the photographic measures, giving all 11 plates the same weight. The mean error of one plate in each co-ordinate is thus found to be $\pm$ ″.0065. The general agreement with the "internal" mean error is so close that the real mean error of one plate is presumably somewhat larger than $\pm$ ″.0065. But even so the accuracy obtained is satisfactory, though a considerable amount of labour is involved in measuring the plates, the total number of settings used here being 14926.

The later plates of α Centauri have been taken with the grating giving 2 magnitudes difference between the central image and the diffraction images of the first order. The images of the second order of the brighter component and of the first order of the fainter one are then nearly of the

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Proceedings Royal Acad. Amsterdam, Vol. XXXVI, 1933.

α Centauri

Date	n_f, n_g	$\Delta\alpha \cos\delta$	m. e.	$O-C$	n_f, n_g	$\Delta\delta$	m. e.	$O-C$	
1929ª·245	116, 116	−6″·511	± ″·006	−″·002	116, 116	−3″·447	± ″·007	″·000	φ
·251	111, 115	6 ·508	7·	— 1	111, 111	3 ·438	8	+ 5	B
·459	140, 139	6 ·423	10	— 2	116, 106	3 ·286	9	— 11	φ
·472	130, 131	6 ·417	7	— 2	135, 141	3 ·261	7·	+ 3	B
1930 ·288	47, 44	6 ·064	9	+ 7	47, 48	2 ·600	11	+ 2	HZG
·291	74, 76	6 ·071	8	— 1	76, 72	2 602	7	— 3	„
1931 ·260	50, 46	5 ·655	14	— 7	46, 40	1 ·795	12	+ 12·	„
·323	70, 73	5 ·611	7·	+ 10	76, 75	1 ·757	8	— 1	„
·348	46, 41	5 ·605	11·	+ 5	41, 46	1 ·737	13	— 2	„
1932 ·412	126, 113	5 ·139	4·	— 9	129, 118	·870	5	— 9	„
·453	221, 224	5 ·110	2·	+ 1	223, 221	·824	3·	+ 3	„

same intensity and have been used for measurement. The accompanying figure shows the appearance of such an image.

One of the most fascinating questions in astronomy is, whether our sun with its planets is an exception from the rule or not. In this connection the fact may be recalled that the mass of the planet Jupiter is about one thousandth part of that of the sun and its distance from the sun about 5 times that of the earth. The displacement of the sun caused by Jupiter has therefore a range of one hundreth of an astronomical unit. The parallax of α Centauri is $''.75$ and the corresponding range of displacement $''.0075$. This is of the same order as the mean error of one plate found above. We are therefore not far from the accuracy required to find evidence of planets belonging to other suns, if such planets exist.

Astronomy. — *Mittlere Lichtkurven von langperiodischen Veränderlichen. XV. W Andromedae.* Von A. A. NIJLAND.

(Communicated at the meeting of September 30, 1933.)

Instrumente S und R. Die Beobachtungen wurden alle auf R reduziert; die Reduktion R—S beträgt $-0^m.35$. Spektrum M7—8e (H. A. **79**, 164). Gesamtzahl der Beobachtungen 767 (von 2416845 bis 2427216). Es wurden wieder, wie in allen früheren Mitteilungen, die in zwei Instrumenten angestellten Schätzungen nur einmal gezählt.

In 52 in der Figur 1 mit v bezeichneten Fällen war der Stern unsichtbar. Es wurden weiter zwei stark abweichende Schätzungen, die übrigens schon *a priori* als sehr unsicher bezeichnet waren, verworfen: 2419927, $v = 12^m.83$ und 2423903, $v = 12^m.49$, und schliesslich die drei ersten, in zwei Instrumenten angestellten Schätzungen, bei denen der Veränderliche wahrscheinlich mit dem Stern BD $+ 43°.462$ verwechselt worden ist. Es bleiben dann 710 Beobachtungen für die Diskussion übrig.

Karte: HAGEN, *Atlas Stell. var. Series VI;* s. auch *Spec. Vat. XII.*

Die Tabelle I giebt eine Übersicht der benutzten Vergleichsterne.

Für die Koordinaten des Sterns m in bezug auf den Veränderlichen ist bei HAGEN $-0^m.34$ anstatt $+0^m.34$ zu lesen. Die photometrische Helligkeit des Sterns φ verdanke ich einer brieflichen Mitteilung von weiland G. MÜLLER. Die Sterne a, b, g und p kamen nur selten zur Verwendung. Von der angeblichen Veränderlichkeit des Sterns x wurde nichts bemerkt; allerdings ist der Stern nur 20-mal als Vergleichstern benutzt worden. Stern s wurde 4-mal (2417063, 7254, 2425996, 6001) an die Grenze von S, die Sterne α und β 28-, bzw. 9-mal bei der Beobachtung des Ver-

TABELLE I. Vergleichsterne.

	BD	HAGEN	St.	HA 91	HA 74	PD	PD *red.*	PARKH.	PARKH. *red.*	*H*
	°			m	m	m	m			m
a	+43.431	—	68.3	6.50 G5	6.28	6.57 WG—	6.42	—	—	6.34
b	+42.489	—	65.7	7.08 G5	—	7.06 WG	6.97	—	—	6.64
c	+43.474	—	63.0	6.96 A2	6.96	7.20 GW	6.93	m 6.85	m 7.06	6.95
φ	+43.459	2	57.0	— G0	—	7.90 WG	7.82	—	—	7.61
g	+42.480	—	54.2	7.61 B9	—	8.23 GW—	7.92	—	—	7.92
l	+43.478	—	50.4	— A3	8.32	—	—	7.89	8.10	8.35
k	+44.446	—	47.6	—	—	—	—	—	—	8.67
m	+43.460	4	43.2	—	8.95	—	—	8.93	9.14	9.16
n	+43.457	3	41.5	—	—	—	—	9.15	9.36	9.34
p	+43.466	7	39.4	—	—	—	—	—	—	9.58
x	+43.462	5	39.3	—	9.55	—	—	9.28	9.49	9.59
q	+43.461	6	37.9	—	9.56	—	—	9.53	9.58	9.75
r	—	19	32.0	—	10.36	Grenze	—	10.12	10.34	10.41
s	—	32	26.0	—	—	m 11.33	—	—	—	11.09
t	—	34	21.0	—	—	—	—	—	—	11.65
u	—	46	18.2	—	—	—	—	—	—	11.97
w	—	54	13.5	—	—	—	—	—	—	12.49
y	—	55	6.6	—	—	—	—	12.42	13.29	13.27
z	—	59	5.7	—	—	—	—	—	—	13.36
α	—	66	1.8	—	—	13.75	—	12.95	13.97	13.80
β	—	71	0.0	—	—	13.91	—	13 61	[14.81]	14.00

änderlichen im Minimum an die Grenze von *R* angeschlossen. Die photometrischen Helligkeiten von PARKHURST wurden dessen *Res. in stellar Phot.* (Wash. 1906) entnommen. Für die Grössen unter $9^m.3$ konnte die Formel $H = P + 0^m.22$ ($H - 9^m.33$) zur Reduktion auf das Harvard-System benutzt werden (AN 4911), wobei allerdings für Stern *β* der offenbar unmögliche Wert $14^m.81$ herauskommt, denn *β* ist bei guter Luft noch gut im Zehnzöller sichtbar. Die Grössen der helleren Sterne bekamen die konstante Korrektion $+ 0^m.21$. Die Stufenskala bezieht sich auf die Helligkeit $10^m.0$; der Stufenwert ist $0^m.112$. Der Anschluss an die photometrischen Helligkeiten ist sehr befriedigend.

Es liegen 82 Schätzungen der Farbe vor, welche für vier Fünftel aus den Jahren 1905 bis 1917 stammen. Aus den Tabellen IIa und II*b* geht

TABELLEN IIa und IIb. Farbenschätzungen.

Zeitraum	n	Farbe	Grösse	n	Farbe
		c	m		c
2416948—2417778	19	3.06	6.34	11	3.00
7788— 8243	19	3.34	6.87	12	2.88
8524— 9428	18	3.06	7.17	12	3.25
9755—2421336	10	3.50	7.53	12	3.50
2422533— 6921	16	3.69	8.09	12	3.06
	82		8.70	12	3.67
			9.62	11	3.73
				82	3.30

hervor, dass sich die Farbenauffassung weder mit der Zeit noch mit der Helligkeit ausgesprochen geändert hat. Das allgemeine Mittel ist $3^c.30$.

Die Figur 1 enthält die Beobachtungen, alle auf R reduziert. Die Reihe der Abweichungen (Beobachtung minus Kurve) zeigt 233 Plus-, 243 Minuszeichen, 234 Nullwerte, 249 Zeichenfolgen, 226 Zeichenwechsel. Das Mittel der absoluten Werte der Abweichungen ist $0^m.109$.

Ein Einfluss des Mondscheines auf die Helligkeitsschätzung ist nicht bemerkbar. Es verteilen sich auf 206 bei Mondschein angestellte Beobachtungen die Abweichungen wie folgt: 74 Plus-, 63 Minuszeichen, 69 Nullwerte.

Die Tabelle III enthält die aus der Kurve abgelesenen Epochen der Minima m und der Maxima M, nebst einer Vergleichung mit den einfachen Elementen R:

$$2421975^d + 398^d E \text{ (für die Minima)}$$

und $$2422137 + 398\ E \text{ (für die Maxima)},$$

welche die beobachteten Epochen leidlich gut darstellen.

Nach der *G und L* (I,55) werden die älteren Beobachtungen befriedigend mittels der Periode $396^d.5$ für die Minima, und $395^d.4$ für die Maxima dargestellt. PRAGER's Katalog für 1933 gibt den Periodenwert $396^d.6$, und das aus sämtlichen von mir seit d.J. 1905 in den *Astr. Nachr.* mitgeteilten Epochen der Minima und Maxima abgeleite allgemeine Mittel ist 397^d.

Die extremen Werte des Lichtwechsels sind:

$$\left.\begin{array}{l} \text{Minimum: } v = 13^m.96 \pm 0^m.044 \\ \text{Maximum: } v = 7.13 \pm 0.120 \end{array}\right\} \text{(m.F.)}.$$

Die Amplitude beträgt somit $6^m.83$. Sowohl beim Minimum wie beim Maximum scheinen die Abweichungen vom Mittelwert regellos aufzutreten.

Auch bei *W Andromedae* unterliegt wieder (s. Fig. 1) die Aufhellung

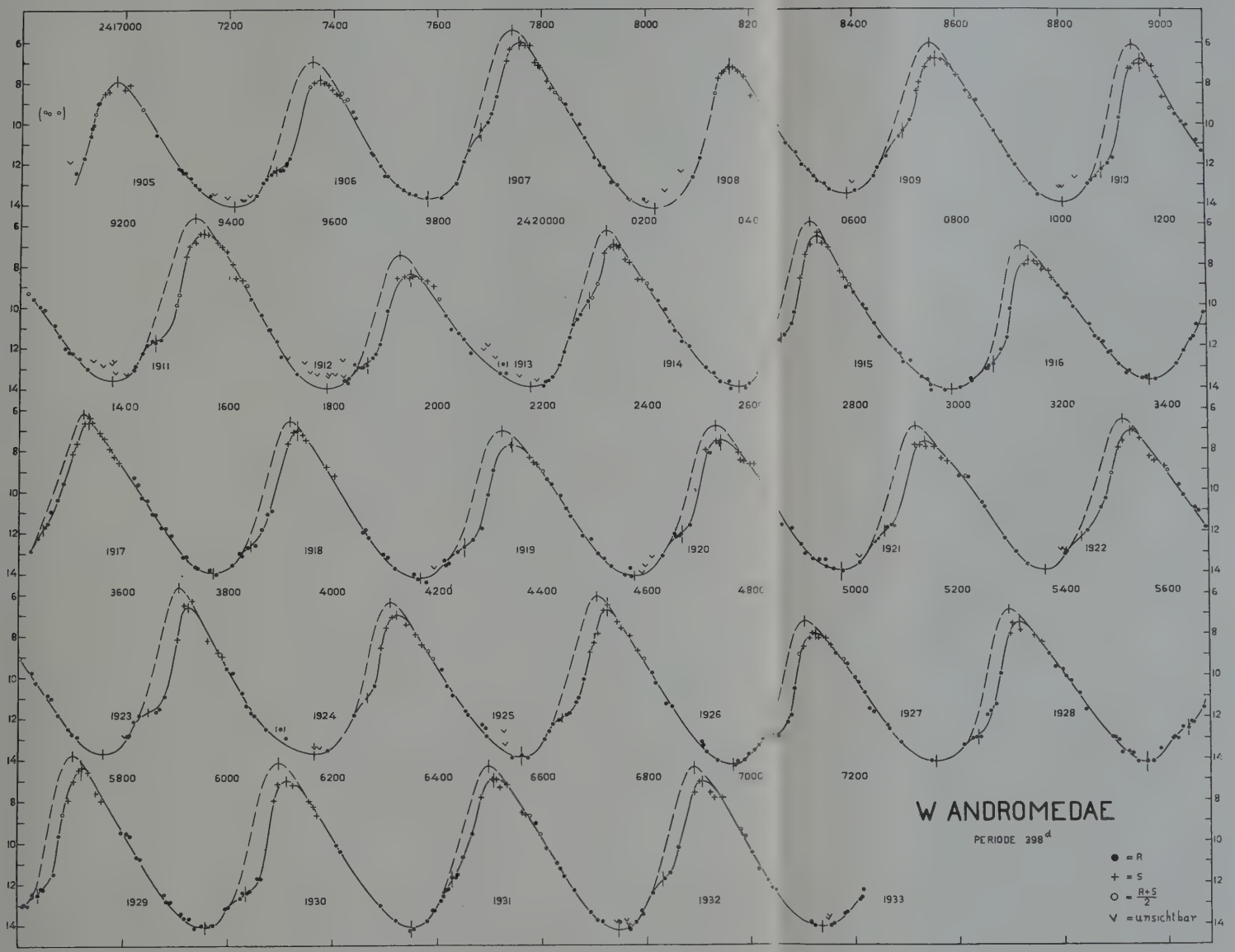

Fig. 1.

TABELLE III.

E	Minima m				Maxima M			
	B	v	R	$B-R$	B	v	R	$B-R$
— 13	—	—	—	—	241 6984	m 7.9⁵	6963	+ 21
— 12	241 7211	m 14.1	7199	+ 12	7375	7.8⁵	7361	+ 14
— 11	7582	13.7	7597	— 15	7757	6.0	7759	— 2
— 10	8018	14.2⁵	7995	+ 23	8162	7.2	8157	+ 5
— 9	8390	13.5	8393	— 3	8562	6.7⁵	8555	+ 7
— 8	8805	14.0	8791	+ 14	8958	6.8	8953	+ 5
— 7	9178	13.6	9189	— 11	9354	6.4	9351	+ 3
— 6	9590	14.0	9587	+ 3	9750	8.4⁵	9749	+ 1
— 5	9980	13.9⁵	9985	— 5	242 0136	7.0	0147	— 11
— 4	242 0379	14.0	0383	— 4	0532	6.6	0545	— 13
— 3	0790	14.1	0781	+ 9	0936	7.8	0943	— 7
— 2	1170	13.6⁵	1179	— 9	1333	6.5⁵	1341	— 8
— 1	1573	13.9⁵	1577	— 4	1734	7.0	1739	— 5
0	1970	14.2	1975	— 5	2144	7.7⁵	2137	+ 7
+ 1	2378	14.1	2373	+ 5	2544	7.5⁵	2535	+ 9
+ 2	2776	13.8⁵	2771	+ 5	2937	7.6	2933	+ 4
+ 3	3165	13.8⁵	3169	— 4	3330	7.1	3331	— 1
+ 4	3563	13.7	3567	— 4	3726	6.6	3729	— 3
+ 5	3966	13.7	3965	+ 1	4124	7.0	4127	— 3
+ 6	4361	13.8⁵	4363	— 2	4525	6.7⁵	4525	0
+ 7	4765	14.2⁵	4761	+ 4	4927	8.0	4923	+ 4
+ 8	5156	14.1	5159	— 3	5315	7.4	5321	— 6
+ 9	5558	14.1⁵	5557	+ 1	5722	6.4	5719	+ 3
+ 10	5957	14.1	5955	+ 2	6114	7.0	6117	— 3
+ 11	6351	14.1	6353	— 2	6507	6.9⁵	6515	— 8
+ 12	6745	14.2⁵	6751	— 6	6906	7.0	6913	— 7
+ 13	7137	14.1	7149	— 12	—	—	—	—
		13.96		± 6⁵		7.13		± 6

einer Verzögerung, welche zwar niemals den Charakter eines eigentlichen Stillstandes annimmt, wie das des öfteren bei anderen Sternen der Fall ist,

aber doch fast immer so deutlich ausgeprägt ist, dass sich im Kurvenzug der Wendepunkt gut angeben lässt. Ausnahmen machen nur die Maxima 6984 und 8162, wo die Beobachtungsdaten dazu nicht ausreichen, und die Maxima 1333 und 6507, wo die Verzögerung nur eben angedeutet ist.

TABELLE IV.

E	*A.* Wendepunkte				*B.* Ungestörte Maxima			
	B	v	R	$B-R$	B	v	R	$B-R$
	241	m			241	m		
− 12	7291	12.3	7283	+ 8	7360	7.0	7345	+ 15
− 11	7684	10.3	7681	+ 3	7744	5.4	7743	+ 1
− 10	—	—	—	—	—	—	—	—
− 9	8498	10.4	8477	+ 21	8550	6.0^5	8539	+ 11
− 8	8880	12.3	8875	+ 5	8941	6.1	8937	+ 4
− 7	9262	11.6	9273	− 11	9336	5.6^5	9335	+ 1
− 6	9669	12.7	9671	− 2	9730	7.5	9733	− 3
− 5	242 0092	9.7	0069	+ 23	242 0125	6.3	0131	− 6
− 4	0462	11.6	0467	− 5	0519	5.9	0529	− 10
− 3	0870	12.8	0865	+ 5	0923	7.1	0927	− 4
− 2	1246	11.8	1263	− 17	1323	6.2	1325	− 2
− 1	1644	12.6	1661	− 17	1720	6.6	1723	− 3
0	2053	12.7	2059	− 6	2125	7.0	2121	+ 4
+ 1	2469	12.0	2457	+ 12	2533	6.8	2519	+ 14
+ 2	2859	12.0	2855	+ 4	2919	6.8^5	2917	+ 2
+ 3	3235	12.3	3253	− 18	3316	6.6	3315	+ 1
+ 4	3648	11.7	3651	− 3	3707	5.6^5	3713	− 6
+ 5	4069	11.0	4049	+ 20	4112	6.4	4111	+ 1
+ 6	4440	12.0	4447	− 7	4505	6.1	4509	− 4
+ 7	4847	12.8	4845	+ 2	4905	7.3	4907	− 2
+ 8	5237	12.8	5243	− 6	5295	6.8	5305	− 10
+ 9	5640	12.4	5641	− 1	5705	5.8	5703	+ 2
+ 10	6034	12.4	6039	− 5	6098	6.1^5	6101	− 3
+ 11	6428	11.8	6437	− 9	6498	6.3	6499	− 1
+ 12	6830	11.8	6835	− 5	6890	6.3	6897	− 7
		11.9				6.41		

Der absteigende Ast ist fast immer ganz glatt; nur in sehr seltenen Fällen (7375, 9750) findet man Spuren einer sekundären Welle im Kurvenzug, denen wohl keine reelle Bedeutung zukommt. Zwecks Bilding einer mittleren Kurve verfuhr ich genau so wie es früher bei *T Cassiopeiae* beschrieben wurde (Proc. **34**, 220). Die Tabelle IV *A* gibt die Epochen der abgelesenen Wendepunkte, nebst der Vergleichung mit den einfachen Elementen *R*:

$$2422059^d + 398^d\, E.$$

Die Helligkeit in dieser Phase des Lichtwechsels ist $11^m.91 \pm 0^m.162$ (m.F.).

Die drei Teilkurven schliessen sich, wie aus der Fig. 2 ersichtlich, auch hier wieder genau an einander an, und liefern zusammen die mittlere Kurve *B* (Tabelle V).

TABELLE V.

Phase	v	Phase	v	Phase	v	Phase	v	Phase	v
d	m	d	m	d	m	d	m	d	m
— 140	10.36	— 60	13.13	+ 20	13.84	+ 100	11.43	+ 180	7.37
— 130	10.75	— 50	13.37	+ 30	13.67	+ 110	10.85	+ 190	7.66
— 120	11.13	— 40	13.57	+ 40	13.37	+ 120	9.97	+ 200	8.04
— 110	11.51	— 30	13.72	+ 50	12.96	+ 130	8.75	+ 210	8.43
— 100	11.88	— 20	13.84	+ 60	12.54	+ 140	7.85	+ 220	8.83
— 90	12.23	— 10	13.92	+ 70	12.26	+ 150	7.30	+ 230	9.23
— 80	12.56	0	13.96	+ 80	12.03	+ 160	7.13	+ 240	9.63
— 70	12.86	+ 10	13.92	+ 90	11.76	+ 170	7.17	+ 250	10.03
								+ 260	10.42

Wird auch bei *W Andromedae* in der üblichen Weise die Kurve von der Störung befreit, so entstehen die ungestörten Maxima, welche (Tabelle IV *B*) mit den einfachen Elementen *R*:

$$2422121^d + 398^d\, E$$

verglichen wurden.

Die maximale Helligkeit wird jetzt: $v = 6^m.41 \pm 0^m.120$ (m.F.).

Die Teilkurve *A* der ungestörten Maxima (Fig. 2) schliesst sich derjenigen der Minima vollständig an. Für die Schiefe der ungestörten Kurve findet man

$$\frac{M-m}{P} = 0.367.$$

Schliesslich wurde die Differenzkurve *A*—*B* gebildet, welche so gut wie vollkommen symmetrisch verläuft. Das Minimum, zu $2^m.35$, fällt auf

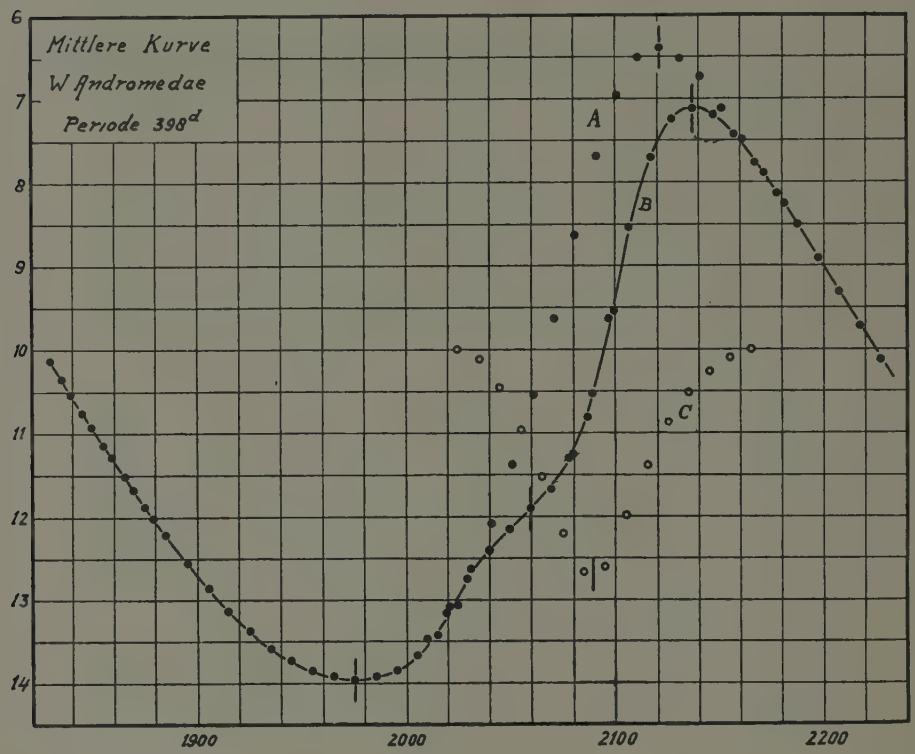

Fig. 2.

2422089, also 32 Tage vor dem ungestörten Maximum; der Veränderliche erleidet beim Aufstieg eine Verfinsterung, welche ihn von 88.5 % seines Lichtes beraubt.

Zusammenfassung.

Aus 767 in den Jahren 1905 bis 1933 (2416845 bis 2427216) angestellten Beobachtungen von *W Andromedae* sind die folgenden Elemente des Lichtwechsels abgeleitet worden:

$$\left.\begin{array}{l}\text{Minimum: } 2421975^d \\ \text{Maximum: } 2422137\end{array}\right\} + 398^d\,E; \qquad \begin{array}{r} v = 13^m.96 \\ v = \quad 7.13 \\ \hline \text{Amplitude} = \quad 6.83.\end{array}$$

Der Stern scheint beim Aufstieg eine Verdunkelung von $2^m.35$ zu erleiden, welche einen symmetrischen Verlauf hat, und deren Minimum auf 2422089 fällt.

Utrecht, Juni 1933.

Chemistry. — *Stationary, checked and other states of osmotic systems.* III. By F. A. H. SCHREINEMAKERS.

(Communicated at the meeting of September 30, 1933.)

Stationary states in osmotic systems, in which more substances can diffuse. (Continuation.)

If we leave an osmotic system

$$inv\ i_1 \,|\, L\,(d + d_1 + d_2 + n) \,|\, inv\ i_2 \ldots\ldots\ldots (1)$$

in which L is a variable liquid, alone, then, as we have seen in Comm. II, a stationary state sets in.

When this variable liquid is "enclosed", then the system

$$inv\ i_1 \left| \begin{array}{ll} m \times stat.\ L\,(d + d_1 + d_2 + n) & \\ P\ def. & m\ def. \end{array} \right| inv\ i_2 \ldots\ldots (2)$$

sets in, no matter whether there are non-diffusing substances yes or no (viz. n zero yes or no). The pressure P, the quantity m and the composition of the stat. liquid will then be completely defined.

When the var. liquid is "open", and it is under a constant pressure, we distinguish two cases. When n is not zero, so that there are one or more non-diffusing substances, we get:

$$inv\ i_1 \left| \begin{array}{ll} m \times stat.\ L\,(d + d_1 + d_2 + n) & \\ P\ const. & m\ def. \end{array} \right| inv\ i_2 \ldots\ldots (3)$$

The quantity and the composition of the stat. liquid now are defined.

When $n = 0$, so that there are no non-diffusing substances, (1) will pass into the system:

$$inv\ i_1 \left| \begin{array}{ll} m \times stat.\ L\,(d + d_1 + d_2) & \\ P\ const. & \triangle\, m \gtrless o \end{array} \right| inv\ i_2 \ldots\ldots (4)$$

The composition of the stat. liquid has also been determined now, but its quantity continuously increases or decreases.

In all these stationary systems the osmosis is going on; so various substances will continuously pass through the two membranes; only in the special case that d in (2) or (3) is zero, the osmosis will be over when the stationary state sets in; I shall refer to this later on.

It also appears from (2), (3) and (4) that the quantity of a stationary liquid can increase or decrease only then, when it is open and does not contain non-diffusing substances.

If we leave an osmotic system

$$inv\ i_1 \mid L_1 \mid L_2 \mid L_3 \mid \mid \mid \qquad \mid inv\ i_2 \ldots\ldots\ldots \quad (5)$$

with an arbitrary number of var. liquids alone, then, as is easy to see, a stationary system will set in now also, which we represent by

$$inv\ i_1 \left| \begin{matrix} stat. \\ L_1 \end{matrix} \right| \begin{matrix} stat. \\ L_2 \end{matrix} \left| \begin{matrix} stat. \\ L_3 \end{matrix} \right| \mid \mid \mid \quad . \quad \mid inv\ i_2 \ldots\ldots \quad (6)$$

Substances diffusing through all membranes will now occur also in all liquids; substances, which can diffuse only through one or more successive membranes, will occur only in the liquids adjoining these membranes. When a var. liquid of (5) contains non-diffusing substances, then they will of course occur in the same quantity in the corresponding stationary liquid of (6).

Each of the stationary liquids of (6) can be enclosed as well as open. For an enclosed stat. liquid the same rules now obtain as in (2), for an open stat. liquid the same as in (3) or (4).

We may also extend these considerations to liquids, which are in osmotic contact with more than two other liquids through more than two membranes and also to the case that there are more than two invariant liquids; in fig. 1 such a tissue with the 4 inv. liquids i_1, i_2, i_3 and i_4 has

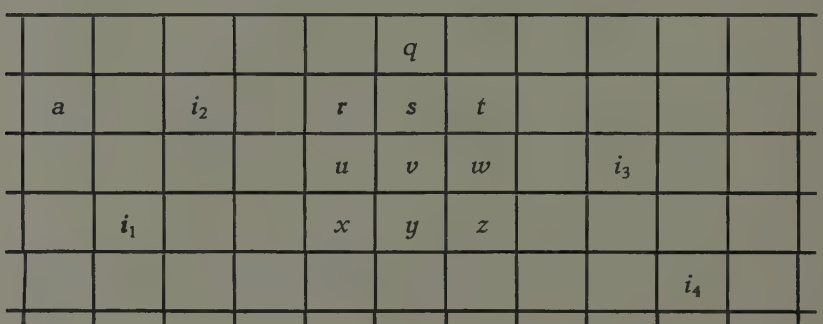

Fig. 1

been drawn. We may imagine these inv. liquids as being currents of liquid,

moving upwards or downwards perpendicular to the plane of drawing. If we now imagine a series of other cells placed on the top of every cell of fig. 1, then every cell (except of course those forming the boundary plane of the tissue) is surrounded by 6 other cells; every invariant current will then be surrounded by four vertical series of cells.

Without further discussion it will be clear that a stationary state now will set in, of which the pressure, the quantity and the composition of the stat. liquid in every cell are defined; they will depend on the factors discussed before, namely the pressure and the composition of each of the inv. liquids, the nature and the surfaces of the different membranes, etc.

When there are d substances (W, X, Y, Z etc.) diffusing through all membranes, then also d diffusing currents will flow through the tissue, namely a W-, an X-, a Y-current etc. The W-current e.g. will flow through the tissue from i_1 towards i_2, i_3 and i_4; the X-current e.g. from i_1 and i_3 towards i_2 and i_4; the Y-current e.g. from i_2 and i_3 towards i_1 and i_4; etc. The occurrence of these currents is not influenced by the presence in, or abscence from each of these d diffusing substances in each invariant current, provided all invariant currents together contain only these d substances.

The water now will have an other distribution of the current [1]) than the substance X; this again an other one than the substance Y, etc. and the diffusing quantities of W, X, Y etc. may be different also.

We may imagine also that the invariant current i_1 also contains a substance R (or more substances) which can diffuse through all membranes, except through those of the invariant currents i_2, i_3 and i_4. As long as the stationary state has not yet set in, also an R-current starting from i_1 will flow through the tissue; this R-current disappears, however, as soon as the stat. state has set in; each of the cells will then have taken in a quantity of R determined by the factors previously discussed and this substance R will then no longer play a part in the osmosis.

If, however, this substance R can besides diffuse through the membranes of one or more of the other inv. currents, e.g. i_3, then, also after the occurrence of the stationary state, the R-current will continue to flow through the tissue from i_1 towards i_3 or reversally.

If we only consider one cell of the tissue (e.g. cell a or s or z) then it is clear that each of the W-, X-, Y- and other currents will generally flow inwards through one or more of the membranes of this cell and flow outwards again through its other membranes. Further it is clear that at every moment in the stationary state as much of each of the diffusing substances W, X, Y etc. in the cell will flow inwards as outwards.

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[1]) For some simple cases of a distribution of the current, when all membranes are permeable for water only, comp. Comm. I.

So in general every W-, X-, Y-current etc. flows in some direction or other through all the membranes of a cell; through one or more of these membranes, however, only a few of these currents can flow; we shall refer to this later on.

We now imagine the special case that only one of the walls of a cell is permeable, e.g. in cell v of fig. 1 only the wall between u and v; then no current will flow through this cell v in the stationary state. The pressure, the quantity and the composition of the liquid in this cell v, which is now in osmotic equilibrium with the stationary liquid of cell u, are now completely defined. If the two cells contain diffusing substances only, then the two liquids have the same pressure and composition; if, however, one or both cells also contain one or more non-diffusing substances, then in general pressure and composition will be different in the two cells [1]).

All that has been said above for óne cell obtains also of course for an arbitrary group of cells (e.g. for group *rsuvw* or group *rstuvwxyz*); then, however, we must pay attention to all the membranes, by which this group is surrounded.

In order to elucidate some of the preceding considerations we first take the osmotic system

$$L(W+n)\,|\,L'(W+n')\rightarrow W \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

in which the membrane is permeable for water only; on the left side are still n, on the right side still n' non-diffusing substances. If we now assume that L' has a greater $O.W.A.$ than L, then, as has been indicated in (7), the water will diffuse $\rightarrow$, namely from the liquid with the smaller towards that with the greater $O.W.A.$ or, in other words: in congruent direction.

As the $O.W.A.$ of a liquid depends not only upon its W-amount but also on its pressure and on its non-diffusing substances, liquid L' can have a smaller as well as a greater W-amount than liquid L. So for (7) the two symbols

$$\underset{\rightarrow}{\geq} W \quad \text{and} \quad \underset{\rightarrow}{\leq} o\star\, W \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

may obtain.

In the first case the water flows positively, namely from the liquid with the greater towards that with the smaller W-amount; in the second one as has been indicated by the sign $\star$ the water flows negatively, namely from the liquid with the smaller towards that with the greater W-amount.

If we apply the above to the adjoining liquids of a stationary tissue,

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[1]) Comp. F. A. H. SCHREINEMAKERS, These Proceedings, **35**, 1038, 1131, 1235 (1932); **36**, 285 (1933).

through which only a current of water flows (Comm. I), then follow among other things:

1°. the water flows through all membranes of the tissue in congruent direction.

2°. the water can flow through the membranes not only positively, but also negatively, or in other words: in a tissue there may be cells (or groups of cells) from which the water flows towards cells (or groups of cells) with a greater W-amount.

We now take a system with a membrane, permeable only for W and X, namely the system

$$L(W+X+n)\,|\,L'(W+X+n'). \quad . \quad . \quad . \quad . \quad . \quad (9)$$

We now may imagine the 4 D.T.'s

$$\begin{array}{ll} a) \leftarrow W \leftarrow X & c) \rightarrow W \leftarrow X \\ b) \leftarrow W \rightarrow X & d) \rightarrow W \rightarrow X \end{array} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

one of which, however, always is incongruent and therefore impossible.

We can easily deduce that now every direction of W and every direction of X may be congruent; it depends upon the pressure and the composition of the two liquids what direction will be so in a special case.

If e.g. the congruent direction of W is $\leftarrow$ and that of X also $\leftarrow$, then (10) passes into:

$$\begin{array}{ll} a) \leftarrow W \leftarrow X & c) \rightarrow oW \leftarrow X \\ b) \leftarrow W \rightarrow oX & d) \rightarrow oW \rightarrow oX \end{array} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

in which the incongruent directions have been indicated by the sign o. The D.T. a now is congruent and d incongruent, so that d is impossible; the three others are possible, however; it depends upon the nature of the membrane which of these three D.T.'s will occur in a special case.

If the congruent direction of the water is $\rightarrow$ and that of X $\leftarrow$, (10) passes into:

$$\begin{array}{ll} a) \leftarrow oW \leftarrow X & c) \rightarrow W \leftarrow X \\ b) \leftarrow oW \rightarrow oX & d) \rightarrow W \rightarrow oX \end{array} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Now the D.T. c is congruent and b incongruent, so that now only the D.T.'s a, c and d are possible [1]).

---

[1]) This always obtains in the special case that n and n' in (9) are zero, so that this system contains the diffusing substances W and X only, and when the liquid with the smaller W-amount is placed on the left side of the membrane.

Because, as has been said already above, every direction of W and every direction of X may be congruent as well as incongruent, each of the 4 D.T.'s of (10) the congruent as well as the incongruent one; it depends upon the pressure and the composition of the two liquids which D.T. will be congruent or incongruent in a special case.

Above we have seen that in system (7) the water can diffuse in positive as well as in negative direction; in system (9) this obtains for the water as well as for the substance X.

Of course corresponding considerations obtain for systems in which more than 2 substances can diffuse; if we call their number d, then, instead of the 4 D.T.'s (10) now 2^d are imaginable; what has been said above obtains for them also.

If we apply the above to the adjoining liquids of a stat. tissue, in which the substances W, X, Y etc. diffuse, then follow among other things:

1°. the substances W, X, Y etc. can flow through the membranes of a tissue not only congruently, but also incongruently; all of them however cannot flow incongruently through the same membrane at the same time.

2°. the substances W, X, Y etc. can flow through the membranes not only positively, but also negatively; or in other words: there can be cells (or groups of cells) in tissues, from which one or more of the substances W, X, Y, etc. flow towards cells (or groups of cells) with a greater amount of these substances.

It appears from the above that the stationary state of a tissue depends upon a whole series of factors, viz. the pressure and composition of each of the invariant currents; upon the nature of the membranes and the ratio of their surfaces; upon the number of membranes of every cell, upon the nature and the quantity of the non-diffusing substances of every cell; upon the volume of every cell under a given pressure and the elasticity of its membranes and walls, etc.

Every change in one or more of these factors will also cause a change in the stationary state, namely an other quantity and distribution of each of the d currents of the tissue [1]); of the pressure and composition of the cells; perhaps also of the transition of congruent into incongruent and of positive into negative osmosis or reversally of one or more of the substances through one or more of the membranes, etc.

If we imagine the membranes between the cells r, s, t, u, v, w, x, y and z left out, so that these 9 cells pass into a single greater cell, then we get fig. 2, in which, however, we must imagine besides cell q of fig. 1.

Now it is clear that the stationary state of this tissue will be quite different from the one in fig. 1. We saw this already for the quantity and

[1]) For the influence which the change in one membrane can have already on the quantity and the distribution of the W-current of a tissue, of which the membranes are permeable for water only, comp. (22) and (24) of Comm. I.

the distribution of the W-current in (14) and (25) of Comm. I; of course this is also the case with all other currents flowing through the tissue.

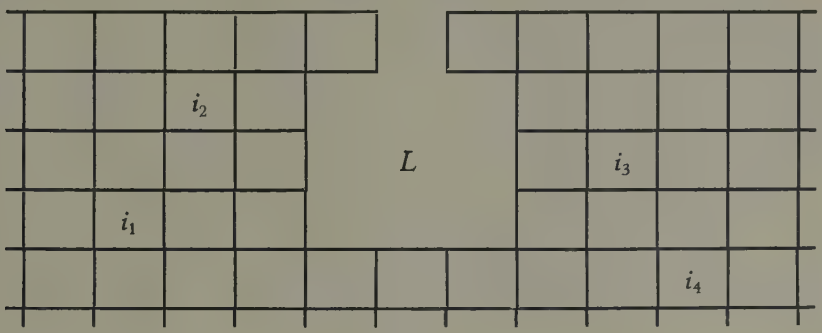

Fig. 2

If we now imagine in the way it has been drawn in fig. 2, that cell q of fig. 1 is omitted too, the stationary state will again become quite different, especially because liquid L now becomes an "open" stationary liquid, e.g. under the pressure of 1 atmosphere.

Previously we have seen (comp. 4 and 6) that the quantity of an open stationary liquid will increase or decrease continuously. If we imagine that this quantity increases, this open cell can be compared to the cavity of a gland and the stationary liquid to the fluid secreted by the gland.

Through each of the numerous membranes of this cavity a W-current will now flow, perhaps inwards through all membranes, perhaps through a few membranes also outwards; of course the same obtains also for each of the other currents. All that has been discussed above regarding congruent and incongruent and positive and negative osmosis, of course obtains also for the walls of this cavity, so that liquid L can contain several substances in greater concentrations than occur in the surrounding tissue.

Now it is also clear that every change in the factors discussed above will also cause a change in the quantity and in the composition of this liquid L. We may even imagine that this quantity now begins to decrease so that the cavity will stop functioning as a gland.

The cause may then be found in the immediate vicinity of the cavity, e.g. in a change of its membrane; it can be found also, however, in the membranes of other cells at a greater distance or in a change in the membranes, the pressure or the composition of one or more of the invariant currents.

It will be clear to the reader, without my emphatic statement of it that in these considerations I would not and could not either give anything but a rough sketch of what in real tissues may take place, in which not only still other factors known to us play a part, but surely also many factors still unknown at the present moment. I shall refer to this later on.

(To be continued).

Leiden, Lab. of Inorganic Chemistry.

Chemistry. — *The Exact Measurement of the Specific Heats of Metals at Higher Temperatures.* XII. *The Specific Heat of metallic Rhenium.* By F. M. JAEGER and E. ROSENBOHM.

(Communicated at the meeting of September 30, 1933.)

§ 1. Metallic *rhenium* (mpt: ca. 3160° C.), obtained from the *Chemische Fabriken* in *Leopoldshall* was enclosed in an evacuated platinum crucible of the usual form and thus used for the determination of the specific heats by means of the metal calorimeter formerly described. *Rhenium* crystallizes in the hexagonal system [1]): it has a closest hexagonal packing with two atoms within its parallelopipedic elementary cell; $a_0 = 2{,}752$ Å.U.; $c_0 = 4{,}448$ Å.U.; $a : c = 1 : 1{,}616$. The specific weight of the metal at 0° C. is: 21,04; its atomic weight: 186.31.

Although the measurements of the specific heats do not betray any allotropic change within the interval of temperatures considered, i.e. between 0° and 1200° C., some particulars observed are worth mentioning. The maximum temperature of the calorimeter was between 0° and 1000° C. reached within 1,5 minutes; but on heating above 1000° C. an appreciable dilatation of the crucible was observed, perhaps as a setting free of occluded gases. Analysis proved the specimen to contain 99,19 % *Re* and 0,81 % oxygen, — which corresponds to about 3,5 % of the volatile Re_2O_7; potassium was not present in any appreciable amount. The gas developed may, therefore, be the oxide. The maximum temperature of the calorimeter then proved to be reached no sooner than within 2,5—3 minutes. Above 1200° C. the deformation of the crucible became so appreciable, that it appeared advisable to stop the measurements at higher temperatures. A meating at 1300° C. for one hour proved to have no influence upon the specific heats found at lower temperatures.

The increase of the temperature $\triangle t$ of the calorimeter above 20° C. in function of the E.M.F. E of the thermoelements is expressed by: $\triangle t = 4{,}15999 \,.\, 10^{-5} \,.\, E - 6{,}3085 \,.\, 10^{-11} \,.\, E^2 + 6{,}1399 \,.\, 10^{-15} \,.\, E^3$.

As the crucibles did not contain more than 7,4520 grammes of *rhenium* and its specific heats are only small, — being about the same as those of platinum, — the results obtained are less accurate than in other cases hitherto studied: the numbers for Q_0 are exact only within about 0,5 % of their values. However, they are sufficiently exact to state the linear

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[1]) V. M. GOLDSCHMIDT, Zeits. f. phys. Chemie, *B*, **2**, (1929), 244; C. AGTE, H. ALTERTHUM, G. HEYNE, K. MOERS und K. BECKER, Zeits. f. anorg. Chem., **196**, (1931), 129; K. MOELLER, *Die Naturwiss.*, **19**, (1931), 575.

dependance of c_p on the temperature, as can be seen from the data collected in the following Table:

Mean specific Heats of Rhenium between 0° and 1201° C.					
Temperature t in °C.:	Final temperature t' of the Calorimeter:	$\triangle t$ of the Calorimeter in M.V.:	Heat developed Q'_0 between t and t' by 1 Gr. of rhenium:	Heat Q_0 developed between $t°$ and 0° by 1 Gr. of the metal:	Q_0 calculated from the formula:
393°.58	20°.53	81.559	12.659	13.328	—
393.72	20.77	85.500	12.662	13.332	—
630.64	21.39	136.181	21.135	21.834	21.847
631.74	20.85	136.268	21.108	21.788	—
631.80	20.82	136.564	21.188	21.867	21.891
801.58	21.12	176.990	27.461	28.149	28.225
801.68	21.01	177.348	27.541	28.226	28.227
1062.2	21.55	242.215	37.662	38.364	38.319
1063.2	21.27	242.211	37.625	38.319	38.357
1064.9	21.26	242.518	37.618	38.311	—
1200.4	22.26	277.530	43.128	43.854	43.864
1200.8	21.46	277.272	43.174	43.874	

The mean specific heat between 0° and 20° C. was: 0,03262.

From these measurements, the quantities of heat Q_0 developed by 1 gr. of *rhenium* between $t°$ and 0° C. can be calculated by means of the formula:

$$Q_0 = 0{,}03256 \,.\, t + 0{,}000003312 \,.\, t^2.$$

Therefore, the mean specific heats can be expressed by:

$$\bar{c}_p = 0{,}03256 + 0{,}3312 \,.\, 10^{-5} \,.\, t$$

and the true specific heats c_p by:

$$c_p = 0{,}03256 + 0{,}6625 \,.\, 10^{-5} \,.\, t.$$

The atomic heats C_p are, therefore, given by:

$$C_p = 6{,}0661 + 0{,}12342 \,.\, 10^{-2} \,.\, t.$$

Some of the values of $\bar{c}_p$, c_p and C_p are thus calculated:

Temperature t in °C.:	Mean specific Heat $\bar{C}_p$:	True specific Heat c_p :	Atomic Heat C_p :
0°	0.03256	0.03256	6.066
100	0.03289	0.03322	6.189
200	0.03322	0.03388	6.312
300	0.03355	0.03455	6.437
400	0.03388	0.03522	6.562
500	0.03422	0.03587	6.683
600	0.03455	0.03653	6.806
700	0.03488	0.03720	6.931
800	0.03521	0.03786	7.054
900	0.03554	0.03852	7.177
1000	0.03587	0.03918	7.299
1100	0.03620	0.03985	7.424
1200	0.03653	0.04051	7.547

The value of $3R$ calories is, for C_p, already surpassed at about — 66° C.

From the measurements of the linear coefficient of the thermal dilatation by BECKER (loco cit.), the value of the mean cubic coefficient of dilation 3α can be deduced; between 15° and 1917° C. v_t can thus be calculated from the formula: $v_t = v\ (1 + 21{,}79 . 10^{-6} . t)$.

As, however, no data for k are available in the literature, c_v and C_v cannot be determined with any appreciable dègree of certainty.

Groningen, Laboratory for Inorganic and Physical Chemistry.

Geology. — *Structure of the Sierra de Baza and adjacent regions in southern Spain.* By H. A. BROUWER and H. JANSEN.

(Communicated at the meeting of September 30, 1933.)

To the east of the basin of Guadix the older rocks of the Sierra Nevada extend northward in the Sierra de Baza, where the overthrust sheets of the Alpujarrides — which are covered by young deposits in the basin of Guadix and only locally appear along its southern margin — have a great extension.

In the Sierra de Baza the same tectonic units as those, which have been distinguished by previous authors in other parts of the northern margin of the betic mountain ranges, are developed. They are from northwest to southeast:

Guajar overthrust sheet
Lanjaron overthrust sheet } Alpujarrides

"Mixed zone" and central crystalline schists } Pennides.

The *Guajar overthrust sheet* consists of crystalline schists and, mostly crystalline, limestones of pre-mesozoic and older-mesozoic age. It has been found in the northwestern part of the Sierra de Baza and probably in an isolated patch near its northeastern part (Zujar). Isolated "klippen" of crystalline schists and limestones rest upon dolomites and limestones of the Lanjaron overthrust sheet. The crystalline schists have a vast extension to the northwest of Gor, where their floor is invisible and where they are covered by tertiary and quaternary deposits. The "klippen" are found in synclines of the Lanjaron overthrust sheet. The axes of the anticlines and synclines in this sheet have a direction from S W to N E and their axes partly converge towards the N E, while the intensity of folding also increases in this direction. The crystalline schists in the Rio de Gor belong to the Guajar overthrust sheet and do not form the crystalline base of the triassic rocks in the Sierra de Baza, as has recently been supposed by BLUMENTHAL [1]). Although the tectonic relations of these crystalline schists are not so clearly visible as in the "klippen" of the Guajar overthrust sheet farther to the south, it is evident from their petrological characteristics (schists with staurolite, andalusite, biotite and chlorite), that they belong to the same higher tectonic unit. The supposition of the same author about the existence of a "schuppen"-structure near Gor has no more been confirmed.

The *Lanjaron overthrust sheet* consists of phyllites, quartzites, limestones, dolomites and mylonitic rocks which mainly are of triassic age. It reaches a great thickness by minor thrusting and has a vast extension to the northwest of the mixed zone. A narrow strip bends to the southeast with the mixed zone along the eastern border of the basin of Guadix, while isolated patches are found still farther to the southeast.

The *"mixed zone"* consists of marbles, limestones, calcareous phyllites, quartzitic albitegneisses, tourmalinegneisses, chloritemicaschists (partly garnetiferous), conglomeratic marls (mylonitic) and ophiolites (diabase, peridotite, serpentine, amphibolite). The Pennides have not been separated yet in different tectonic units, in the "mixed zone" part of the penninic

[1]) MOR. M. BLUMENTHAL. Das Paläozoikum von Malaga als tektonische Leitzone im alpidischen Andalusien. Geol. Rundschau XXIV, 1933, p. 177, Profile 5.

mesozoic and probably the younger palaeozoic are represented. This zone forms a strip with a direction from northeast to southwest along the southeastern border of the Alpujarrides. In its southwestern part it bends to the northwest (along an axial elevation in the crystalline schists) and back to the southeast along the eastern border of the basin of Guadix, where digitations of the mixed zone and the central crystalline schists are found.

Farther to the north the mixed zone is locally uncovered in a window to the southeast of Gor, which is surrounded by the rocks of the Lanjaron overthrust sheet. One of the synclines of the Lanjaron overthrust sheet, which have been mentioned in connection with the "klippen" of the Guajar overthrust sheet can be followed in the window of Gor as a depression between cores of central crystalline schists.

The mixed zone is interrupted to the east of the Sierra de Baza, where it is covered by the young deposits of the basin of Baza. To the east of Rejano it reaches a great thickness along the northern margin of the Sierra de los Filabres. *Here it is thrusted over the Alpujarrides,* as in the neighbourhood of Seron [1]). Near Alcontar windows of triassic limestones, phyllites and gypsum of the Alpujarrides are surrounded by marbles, chloritemicaschists and garnetmicaschists of the mixed zone.

The *central crystalline schists* are micaschists, which often are garnetiferous. They mostly contain graphite and chlorite. Chloritoid and epidote also occur in these rocks. The central crystalline schists form the southern part of the Sierra de Baza and are connected with those of the central parts of the Sierra Nevada and the Sierra de los Filabres.

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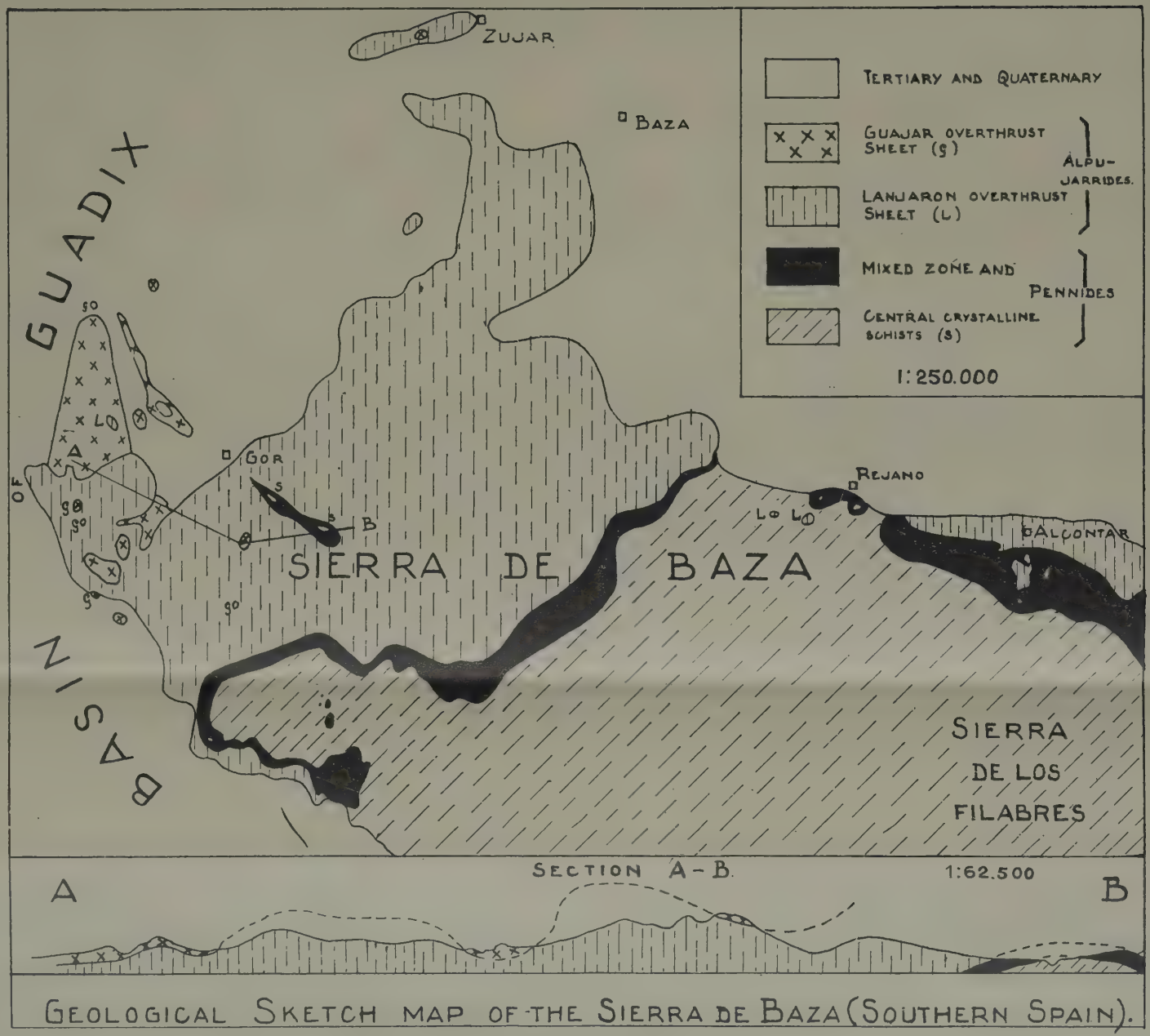
[1]) H. A. BROUWER and C. P. A. ZEYLMANS VAN EMMICHOVEN. The tectonics of the central part of the Sierra de los Filabres (South-Spain). These Proceed. XXVIII, 1924, p. 55.

Botany. — *Über den Einfluss des Lichtes auf die Protoplasmaströmung von Avena.* Von H. P. BOTTELIER. (Communicated by Prof. F. A. F. C. WENT.)

(Communicated at the meeting of September 30, 1933).

Über den Einfluss des Lichtes auf die Protoplasmaströmung ist wenig Bestimmtes bekannt geworden. HOFMEISTER (8) sah bei Myxomyceten nach Belichtung eine Verringerung der Strömungsgeschwindigkeit auftreten. Auch N. PRINGSHEIM (12) und EWART (7) fanden eine Verzögerung der Protoplasmaströmung unter Einfluss des Lichtes bei Characeen, Spirogyra, Vallisneria, u.s.w. Das hierbei benutzte Licht war aber so intensiv, dass es oft schon in wenigen Minuten eine starke Schädigung



GEOLOGICAL SKETCH MAP OF THE SIERRA DE BAZA (SOUTHERN SPAIN).

des Versuchsobjektes herbeiführte. LUERSSEN (10) untersuchte den Einfluss farbigen Lichtes. Er fand im roten Lichte eine stärkere Hemmung als im blauen Lichte. Nach EWART beruht dieses Ergebnis auf einer stärkeren Erwärmung des Objektes im roten Lichte, aber blaues Licht hat mehr Einfluss.

Bei Avena konnte BRAUNER (4) in intakten Koleoptilen eine starke Plasmaströmung beobachten. Diese Beobachtung wurde später von F. W. WENT (13) bestätigt. Beide glauben, dass der Wuchsstoff (BRAUNER spricht von Hemmstoffen) von der Protoplasmaströmung transportiert wird. VAN DER WEY (14) stimmt dieser Auffassung nicht bei.

Es erschien mir in diesem Zusammenhang angebracht, die Protoplasmaströmung bei Avena näher zu untersuchen. In vorliegender Arbeit wird, ohne auf die Frage des Auxintransportes näher einzugehen, berichtet über die Beeinflüssung der Protoplasmaströmung durch kurze Lichtreize.

Als Versuchspflanzen benutzte ich etwa 90 Stunden alte Keimlinge, die in der im Utrechter Institute üblichen Weise herangezogen waren.

Es zeigte sich, dass intakte Koleoptilen nicht geeignet sind zu zuverlässigen Messungen. Es wurde darum das zu verwendende Koleoptil median halbiert, das Primärblatt entfernt und beide Hälften zwischen Objektträger und Deckglas eingeklemmt. Das Präparat wurde sodann in Wasser in einen Mikrothermostaten nach HILLE RIS LAMBERS (9) gelegt. Die Beobachtung geschah mit Zeiss Objektiv 60 × und Okular 10 ×, also bei 600-facher Vergrösserung. Man bekommt so ein ziemlich klares Bild, zumal von den Epidermiszellen. Für die Beobachtung wurde orangefarbiges Licht benutzt von einer, mit einem Schott'schen OG 2 Lichtfilter versehenen 40 W starken Glühlampe. Für dieses Licht ist die Protoplasmaströmung, wenn überhaupt, sehr wenig empfindlich (näheres siehe unten). Als Lichtquelle benutzte ich eine Quecksilberlampe, aus deren Licht mit Hilfe von Schott'schen Lichtfiltern verschiedene Wellenlängen isoliert wurden (über Verwendung u.s.w. dieser Filter s. NUERNBERGK (11) S. 769). Die Energie des benutzten Lichtes wurde mit einer Moll'schen Thermosäule in Verbindung mit einem Schleifengalvanometer gemessen. [1])

Es wurde nur die Strömung in den Epidermiszellen beobachtet, weil die Strömung in den Parenchymzellen meist zu unregelmässig war. Die Leukoplasten, die mit der Strömung mitgerissen werden, zeigen eine sehr unregelmässige Bewegung; nur die kleinsten Körper bewegen sich mit annäherend konstanter Geschwindigkeit; es konnten also nur letztere für die Messungen verwendet werden.

Die Koleoptilpräparate zeigen sofort nach dem Schneiden eine starke Protoplasmaströmung, die 3—4 Tage lang andauert; sie können wachsen

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[1]) Für die Überlassung dieser Apparate bin ich Herrn Dr. E. NUERNBERGK zu grossem Dank verpflichtet.

und phototropische Krümmungen ausführen. Wir dürfen also annehmen, dass sie sich nicht in sehr abnormaler Lage befinden. Um einen etwaigen Einfluss der Verwundung möglichst auszuschalten, wartete ich nach dem Schneiden 2 Stunden, bevor ich mit den Versuchen anfing.

Ich bespreche erst den Einfluss des blauen Lichtes.

I. Blaues Licht ($\lambda = 4360$ Å).

Eine kurze Belichtung ruft 3—4 Minuten später eine Verzögerung der Plasmaströmung hervor, die nach 8—10 Minuten fast völlig wieder aufgehoben ist (Fig. 1).

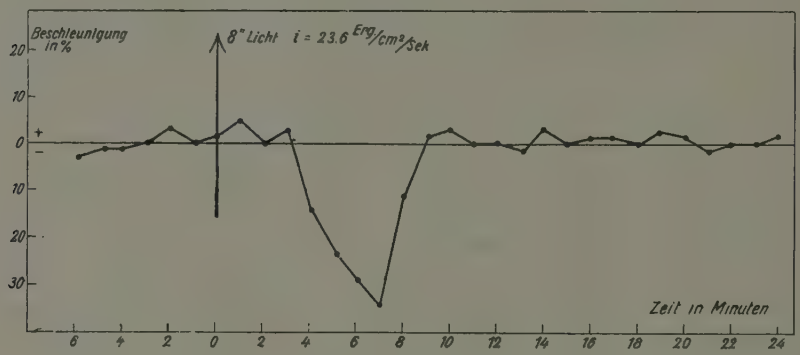

Fig. 1. Hemmung der Protoplasmaströmung durch Licht. $\lambda = 4360$ Å.

Es wurden bestimmt:

1. Die mittlere Strömungsgeschwindigkeit pro Minute (4 Messungen p./Min.).
2. Die Strömungsgeschwindigkeit im ungereizten Zustand (50 Messungen, mittlerer Fehler 1—3 %).
3. Die Differenz: Minutenwert minus normale Geschwindigkeit, ausgedruckt in % der normalen Geschwindigkeit.

Als Grösse der Reaktion wurde angenommen die algebraische Summe dieser Differenzen.

Eine kurze Belichtung ruft eine geringe Verzögerung hervor. Bei zunehmender Belichtungszeit nimmt die Reaktionsgrösse zu, zuerst etwas schneller als proportional, später langsamer. Bei noch längerer Belichtungszeit nimmt die Reaktionsgrösse wieder ab und schliesslich wird die Plasmaströmung vom Lichte beschleunigt (siehe Fig. 2). Diese Versuche habe ich bis jetzt mit 4 Intensitäten vorgenommen:

2.4, 5, 11 und 23.6 Erg/cm²/Sek.

Wie aus Fig. 2. hervorgeht, wird die Reaktionsgrösse ausschliesslich bestimmt durch die Grösse des Produkts Intensität $\times$ Belichtungszeit. *Sowohl für die Verzögerung als für die Beschleunigung der Protoplasmaströmung gilt also die Produktregel* (das Reizmengengesetz). Aus dem Versuch mit Intensität $i = 2.4$ Erg/cm²/Sek. (siehe Fig. 2, punktierte

Linie) geht hervor, dass die Regel nur gilt, wenn die gesammte Energiemenge innerhalb etwa 180 Sek. zugeführt wird.

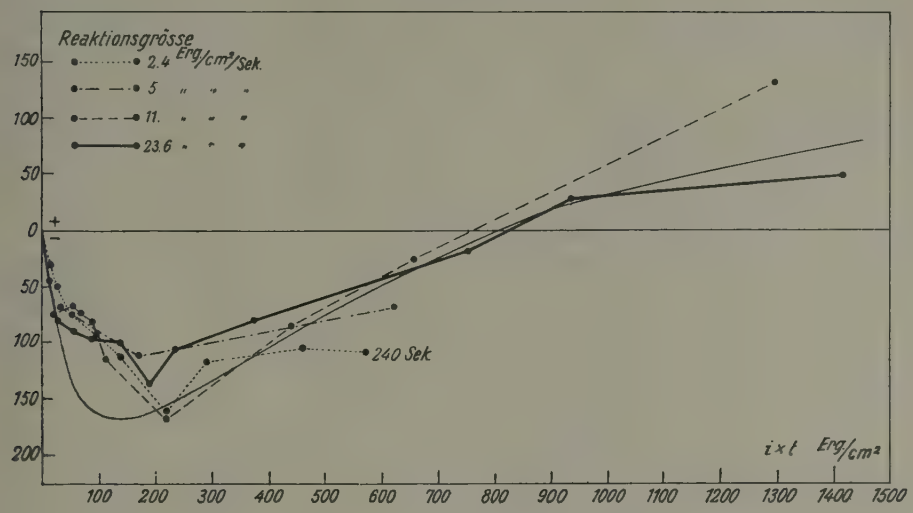

Fig. 2. Reaktionsgrösse als Funktion der Reizmenge. $\lambda = 4360$ Å.

Die dünn ausgezogene Linie in Fig. 2 gibt die Beziehung zwischen Energiemenge und Reaktionsgrösse für die Lichtwachstumsreaktionen nach VAN DILLEWIJN (6), wenn man annehmen darf, dass 1 Erg/cm²/Sek. bei einer Wellenlänge $\lambda = 4360$ Å mit 10 M.K. weissen Lichtes gleich gestellt werden kann. Es muss aber bemerkt werden, dass dieser *quantitativen* Übereinstimmung kein grosser Wert beizumessen ist, denn 1°. ist der Umrechnungsfaktor 10 nie genau bestimmt und 2°. kann nicht ermittelt werden, wieviel Licht gerade die beobachtete Zelle bekommt. Wichtiger erscheint mir darum die Tatsache, dass die Plasmaströmungsreaktionen eine *ähnliche* Beziehung zeigen zwischen zugeführter Energie und Reaktionsgrösse wie die Lichtwachstumsreaktionen. Es gibt noch einige Tatsachen, die daraufhinweisen, dass es Beziehungen zwischen beiden Vorgängen gibt:

a. ARISZ (1) fand bei Avena, dass „rein negative Krümmungen" nur auftreten, wenn die zur Erzeugung einer negativen Krümmung gerade notwendige Lichtmenge innerhalb etwa 200 Sek. zugeführt wird.

b. Ebenso fand DU BUY (5) dass die zur Erzeugung einer 3.-positiven Krümmung gerade notwendige Lichtmenge innerhalb etwa 150 Sek. zugeführt werden muss, damit die Krümmung auftritt.

Auch bei den Strömungsreaktionen muss die gesammte Energiemenge innerhalb etwa 180 Sek. zugeführt werden, damit das zu erwartende Resultat eintritt.

II. Spektrale Empfindlichkeit.

Als ich den Zusammenhang zwischen Energiemenge und Reaktions-

grösse für blaues Licht festgestellt hatte, war es möglich die Empfindlichkeit für Licht anderer Wellenlängen in einfacher Weise zu ermitteln. Es wurde für jede Wellenlänge die Reaktionsgrösse für 2—3 Energiemengen bestimmt (Mittelwert aus 8 Versuchen) und dann in Fig. 2 aufgesucht, welche Energiemengen für blaues Licht erforderlich waren, um gleichgrosse Reaktionen hervorzurufen. Das Verhältnis zwischen beiden Energiemengen ist die Empfindlichkeit für die untersuchte Wellenlänge bezogen auf blaues Licht.

Um die Empfindlichkeit für gelbes Licht zu messen, wurde die Beobachtung im roten Lichte angestellt (*RG* 1 Filter von Schott). Es konnte bei der grössten verwendbaren Energiemenge keine messbare Reaktion hervorgerufen werden. Es war also gestattet, gelbes Licht für die Beobachtung in den oben beschriebenen Versuchen zu benutzen.

TABELLE.

Empfindlichkeit der Protoplasmaströmung für Licht von verschiedenen Wellenlängen.

Farbe	Wellenlänge in Å	Empfindlichkeit
u. violet	3660	10
violet	4050	45
blau	4360	100
grün	5460	3
gelb	5780	0?

Die Tabelle gibt eine Übersicht über die gefundene Empfindlichkeitsverteilung im Spektrum, wenn die Empfindlichkeit für Blau = 100 gestellt wird.

Auch hier finden wir also eine gute Übereinstimmung mit den Angaben von BLAAUW (3), BACHMANN und BERGANN (2) und DU BUY für die Empfindlichkeitsverteilung im Spektrum bei den phototropischen Krümmungen.

Eine ausführlichere Mitteilung wird später folgen.

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Botanisch Laboratorium.

Utrecht, September 1933.

Physiology. — *Zur Frage der Holzverdauung durch Insektenlarven.* Von K. MANSOUR und J. J. MANSOUR—BEK. (Aus dem Zoologischen Institut der ägyptischen Universität zu Kairo.) (Communicated by Prof. H. JORDAN.)

(Communicated at the meeting of September 30, 1933.)

Die Frage, ob die holzfressenden Insektenlarven wirklich Holz als Nahrung benutzen können, ist noch nicht endgültig gelöst. Kompliziert wird das Problem dadurch, dass man in vielen von den betreffenden Insekten Mikroorganismen antrifft. In den Fällen wo solche Mikroorganismen sich im Darmlumen befinden, wie in den Termiten und in einigen Lamellicornier-larven, ist die Rolle der dort vorkommenden Protozoën bzw. Bakterien und Flagellaten noch ziemlich eindeutig; CLEVELAND (1924, 1925, 1928) und WERNER (1926) nehmen an, dass die Insekten die Produkte der Zelluloseverdauung durch die Mikroorganismen zu sich nehmen, während dagegen WIEDEMANN (1930) auf Grund eingehender Versuche schliesst, dass die von ihm untersuchten Insektenlarven die in ihrem Darm wachsenden Mikroflora als eigentliche Nahrungsquelle benutzen.

Wo aber in Insektenlarven intracellulare Mikroorganismen vorkommen, entweder im Epithel des Darmes oder in speziellen Organen, ist die Rolle, welche diesen Mikroorganismen für die Verdauung des Holzes zugeschrieben wird (BUCHNER 1928, 1930) ganz hypothetisch. Die Annahme einer solchen Hilfe, wie sie auch UVAROV (1929), in seiner Zusammenstellung der Literatur über die Nahrung der Insekten vertritt, fusst auf der Voraussetzung, dass Insektenlarven keine Enzyme in ihrem Darmkanal besitzen, welche im Stande sind Holz oder Zellulose aus Holz zu hydrolysieren, welche Voraussetzung sich als irrig erwiesen hat.

Die Frage war also, die Verdauungsenzyme einiger Insektenlarven, wo keine Mikroorganismen vorkommen, zu untersuchen mit Rücksicht auf die Möglichkeit einer Verdauung der in Holz vorkommende Stoffen.

Zur Untersuchung kamen zwei Coleopteren-larven, und zwar von Macrotoma palmata und Xystrocera globosa. Beide Arten gehören zur Familie der Cerambycidae, welche viele Holzfresser unter ihren Gliedern zählt.

Macrotoma palmata bohrt im Holze von Morus alba, die Maulbeere, und zwar trifft man sie sowohl im Splintteil des Holzes sowie im Kernholz. Auch findet man die Larven oft im Kernholz von Albizzia lebbek, einer der Mimosaceae.

Xystrocera globosa bohrt ihre Gänge auch im Holz von Albizzia lebbek, doch findet man sie ausschliesslich im Splintholz.

Die Larven der zwei Arten sind einander äusserlich sehr ähnlich, doch zeigen sich Verschiedenheiten, wenn der Darm freigelegt wird; die Macrotoma-larve unterscheidet sich durch die Anwesenheit eines wohlentwickelten Kropfes. Die dicke, chitinöse Innenwand dieses Organes ist mit scharfen Zähnen besetzt, hierduch wird das aufgenommene Holz wie in einer Mühle fein zermahlen.

Die beiden Larven-arten sind ganz frei von Mikroorganismen, es kommen weder besondere Organe (Mycetome) vor, noch sind im Darmtraktus Mikroorganismen vorhanden, wie an Ausstrichen und Querschnitten festgestellt wurde.

Der Magensaft von einer Anzahl Larven von *Macrotoma palmata* wurde nach Zentrifugieren benutzt. Qualitativ konnte das Vorhandensein eines Zellulose-spaltenden Enzymes nachgewiesen worden, indem wir den Magensaft auf Salatstengel- und Dattelkern-schnitte einwirken liessen; die Zellwände (Färbung mit Chlorzinkjod) waren nach einem Tag teils, nach zwei Tagen ganz verschwunden.

Quantitative Versuchen, in welchen die Spaltung von Zellulose gemessen wurde mittels Titration der entstandenen Glukose, zeigten dass der Magensaft im Stande ist, native Zellulose (in Form von stärkefreiem Filtrierpapier) zu einem grossen Teil zu verdauen. Für die Titration wurde die von HAGEDORN und JENSEN (1922) beschriebene Methode benutzt, welche für die geringen Mengen des Magensaftes, welche zur Verfügung standen, besonders geeignet ist. Einige der Ergebnisse sind dargestellt in der Tabelle.

Eine Analyse des Holzes von Morus alba, worin die Macrotoma-Larven gefunden wurden, ergab, dass die Menge der Stärke und der löslichen Zucker in diesem Holze nur sehr gering ist (siehe Tabelle 2) ebenso wie in dem Kernholz von Albizzia labbele, worin man sie auch oft findet.

Die Macrotoma-Larven decken ihren Kohlehydratbedarf also mit den Produkten der Zelluloseverdauung durch ihre passenden Enzyme.

Von Xystrocera globosa wurde auch der Magensaft einer Anzahl Tiere zentrifugiert vor dessen Benutzung in den Verdauungsversuchen. Bei den qualitativen Versuchen war gar keine Auflösung der Zellwände zu bemerken. Auch die quantitativen Messungen der Zellulosespaltung, welche wieder mit der Titration nach HAGEDORN—JENSEN ausgeführt wurden,

ergaben dass native Zellulose gar nicht angegriffen wird (siehe Tabelle 1). Ebensowenig wirkt der Magensaft auf umgefällte Zellulose, und auf mit Schweizersche Flüssigkeit behandeltes Filtrierpapier. Eine Amylase, welche in ihrer Wirkung stärker ist als diejenige von Macrotoma, wurde nachgewiesen.

Eine Analyse des Splintholzes von Albizzia lebbek, welches die Xystrocera-Larven beherbergt, ergab einen erheblichen Gehalt dieses Holzes an Stärke und löslichen Zuckern (Tabelle 2). Dieser Fund und die Abwesenheit einer Zellulose berechtigen zu dem Schluss, dass die Xystrocera-Larven ihren Kohlehydrat-Bedarf decken aus den Zuckern und der Stärke des Holzes, worin sie leben.

Das Kernholz von Albizzia lebbek hat dagegen einen nur sehr geringen Gehalt an Zucker und Stärke, und es ist bedeutungsvoll, dass man die Xystrocera-Larven dann auch nie in diesem Teil des Holzes antrifft.

Es ergibt sich also aus den Versuchen, dass es zwei Typen der mikroorganismenfreien holzfressenden Insektenlarven gibt.

Der erste Typus, zu welchem Xystrocera gehört, kann nur die löslichen Zucker und die Stärke, welche im Holz anwesend sind, zur Verdauung benutzen, das Holz worauf sie leben hat einen hohen Gehalt an diesen Stoffen. Zu dieser Kategorie gehören Xystrocera, Cossus cossus (RIPPER 1931) und wahrscheinlich einige Arten der Familie Bostrychidae, welche im Holze von Poruciania regia und Tamarix sp. (s. Tabelle 2) vorkommen. Die Art der Nahrung macht es notwendig, dass die Larven grosse Mengen des Holzes aufnehmen, um daraus genügend Nahrungsstoffe zu bekommen. Die Menge der Exkrete dieser Tiere ist dann auch ungemein gross.

Der zweite Typus, welcher von Macrotoma vertreten wird, verdaut die Zellulose des Holzes mittels dazu geeigneten Enzymen des Darmkanals. Die Holzarten auf der man die Larven dieses Typus findet, haben einen niedrigeren Gehalt an Stärke und Zuckern. Diese Weise der Holzverdauung findet man bei den Larven von Macrotoma, Cerambyx cerdo (RIPPER 1931) und Hylotrupes bajulus (FALEK 1930). Aus dem Holz, welches im Kropf von Macrotoma fein zermahlen wird, wird die Zellulose gespalten; für diese Tiere kann also weniger Nahrung genügen, die Exkrete sind dementsprechend viel weniger in Menge als diejenigen von Xystrocera.

Die beiden Typen der holzfressenden Insektenlarven sind in ihren Verdauungsprozessen (sei es der Zellulose oder von Stärke und Zucker) ganz unabhängig von Mikroorganismen. In verwandten Arten von Insektenlarven, bei welchen Mikroorganismen im Darmepithel (Leptura rubra und Rhagium spp) oder intracellular (Xestobium rufovillosum) vorkommen, konnte RIPPER (1931) auch eine Zellulosespaltung durch den Magensaft zeigen. Hieraus kann man mit Rücksicht auf die oben angeführten Befunde, nur den Schluss ziehen, dass das Vorkommen von Mikroorganismen ganz gleichgültig und bedeutungslos ist für die Holzverdauung der

Insektenlarven. Von einer Symbiose in dem Sinne dass die Mikroorganismen Hilfe leisten bei der Verdauung, ist keine Rede.

TABELLE 1.

Quantitative Versuche über die Verdauung von Zellulose durch Magensaft von Larven von Macrotoma palmata und Xystrocera globosa.

Ansatz jedesmal 0.5 ccm, enthaltend
6 mgr. Zellulose (stärkefreies Filtrierpapier).
0.2 ccm. Pufferlösung 1/5 mol.
0.3 ccm. Magensaft,
$T = 32°$ C, Pro Titration 0.05 ccm.

Tierart	Magensaft von	P_H des Gemisches	Zeit der Verdauung	Spaltung der Zellulose	
				Zunahme der Glukose in mg.	Spaltung in %
Macrotoma palmata	2 Tieren = 0.5 ccm. Saft	6.3	24 St.	0.093	14
„	„	6.3	2 × 24 St.	0.181	28
Xystrocera globosa	6 Tieren = 0.6 ccm. Saft	6.3	24 St.	0.01	0
„	„	6.3	2 × 24 St.	0.01	0
„	„	6.3	3 × 24 St.	0.01	0
„	5 Tieren = 0.8 ccm. Saft	8.0	3 × 24 St.	0	0
„	8 Tieren = 0.7 ccm. Saft	4.3	24 St.	0	0

TABELLE 2.

Menge der löslichen Zucker und der Stärke in einigen Holz-Arten, ausgedrückt in % des Trockengewichts.

Holzart	Zucker in %	Stärke in %	Total (Zucker + Stärke) in %
Morus alba	0.27	0.2	0.47
Albizzia lebbek Kernholz	0.2	0.5	0.7
„ „ Splintholz	6.2	3.9	10.1
Tamarix sp.	2.8	4.4	7.2
Poincinea regia	1.1	4.5	5.6

Eine dritte und ganz besondere Gruppe der holzfressenden Insekten wird gebildet durch solche, welche freilebende Mikroorganismen in ihrem Darm beherbergen, wie die Protozoen-enthaltenden Termieten, oder die Bakterien und Flagellaten besitzenden Lamellicornier-larven.

Die Arbeit von WIEDEMANN (1930) hat es annehmlich gemacht dass die Lamellicornierlarven (und das nämliche gilt vielleicht für Termieten) keine echten Holzfresser sind ; vielmehr benutzen sie die Mikroorganismen, welche mit der Nahrung aufgenommen oder in Darmtraktus in speziellen Kämmern kultiviert werden, als direkte Nahrungsquelle.

Zusammenfassung.

Die wahren holzfressenden Insekten sind für die Verdauung des Holzes nicht von Mikroorganismen abhängig. Es gibt zwei verschiedene Typen:

A. Ohne Zellulosespaltende Enzyme (Xystrocera globosa). Die Larven dieses Typus erhalten die notwendigen Kohlehydrate aus den Zuckern und der Stärke welche in dem Holz worauf sie leben, in genügender Menge vorkommen.

B. Mit Zellulose-spaltender Enzyme (Macrotoma palmata).

Die Larven dieses Typus decken ihren Kohlehydratbedarf mit den Produkten der Zelluloseverdauung, welche Spaltung von ihren Darmsekreten vollführt wird. Sie können daher auf Holzarten leben, welche arm sind an Stärke und Zuckern.

Die holzfressenden Insekten, wo freilebende Mikroorganismen im Darmlumen vorkommen, wie die Termiten und die Lamellicornierlarven, verdauen das Holz nicht mit Hilfe dieser Mikroorganismen, doch nähren sich direkt von dieser Darmflora. Insekten von diesem Typus haben als Nahrung Mikro-organismen, nicht Holz.

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